



US Army Research Laboratory

Weapons and Materials Research Directorate

Multifunctional Protective Coatings for Land Vehicles

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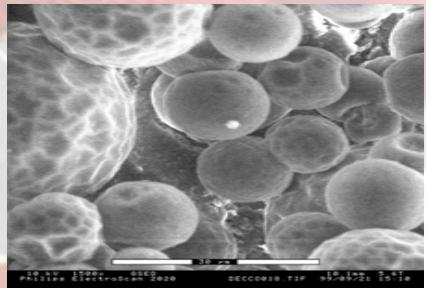
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Courtesy of U.S. DoD



Report Documentation Page			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE SEP 2009	2. REPORT TYPE	3. DATES COVERED 00-00-2009 to 00-00-2009		
4. TITLE AND SUBTITLE Multifunctional Protective Coatings for Land Vehicles		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U. S. Army Research Laboratory, Weapons & Materials Research Directorate, Aberdeen Proving Ground, MD, 21005		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES ASETSDefense 2009: Sustainable Surface Engineering for Aerospace and Defense Workshop, August 31 - September 3, 2009, Westminster, CO. Sponsored by SERDP/ESTCP.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 32
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified		



Courtesy of U.S. Army

- ***Who we are & What we do.....***
- ***Coatings Systems for Land Vehicles***
 - ***Current and future***
 - ***Low Solar Absorbing Coatings***
 - ***UV Cure***
 - ***Near Zero or Zero VOC***
- ***GAPS to address and Considerations for Coatings Advancement***



Courtesy of U.S. DoD



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

- **ARL is the Lead DOD R&D Activity for CARC**
 - Innovative formulations approaches
 - New raw materials selections
 - Advanced characterization
- **Maintains Ownership for all key specifications regarding pretreatments, primers and topcoats for all tactical and related support equipment and munition coatings.**
- ❖ *Elements above assist to implement and transition products*

Environmental

Survivability

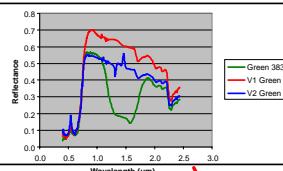


Durability

- Develop materials for military unique coatings including pretreatments, primers, and topcoats
 - Chemical Agent Resistant Coatings
 - Munitions coatings
 - Industrial coatings for vehicle interiors
- Produce materials and coatings that balance three critical requirements
 - Survivability (camouflage, chemical agent resistance)
 - Durability (appearance, corrosion, compatibility, etc.)
 - Environmental (compliance and pollution prevention)
- Implement and transition new products
 - Specifications and Standards
 - Troubleshooting, consulting, and problem solving
- Analyze and solve technical problems related to coatings systems used on Army Materiel

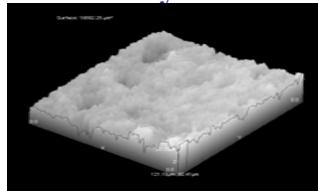
Reflectance

- Specular (gloss)
- Spectral (color)
- IR Spectra



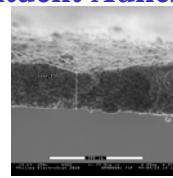
Microscopy

- Physical Changes At Surface
- Failure Analysis



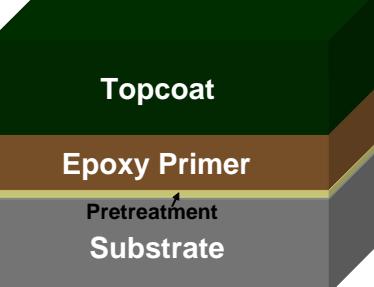
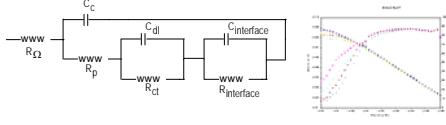
SEM Coating X-section

- Fracture Surface of System
- Constituent Adhesion



EIS

- Equivalent Circuit Models of Corrosion Behavior



Accelerated Weathering

- Durability, thermal/ irradiated degradation, moisture sensitivity



Adhesion Testing

- Durability, flexibility, strength

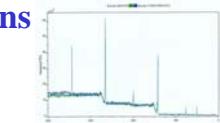
Chemical Structure and Transport Properties

- FTIR/ATR, Raman, GC-MS



SEM-EDX, SAM, XPS, UV-VIS

- Chromium concentrations
- Oxidation states



Accelerated Corrosion Testing

- Permeability, corrosion resistance

DMA, DSC

- T_g , stiffness, cross-link density, extent of cure

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Today**CARC Camouflage
Polyurethane Topcoat
(1.8 mil)**

- Visible and NIR
- Silica extender
- Semitransparent binders

**CARC epoxy primer
(0.8 - 1.2 mils)****Chemical Conversion
Coating (0.2-0.3 mil)****Substrate
(ferrous or nonferrous)****Tomorrow****Tailored CARC Coating**

- Functional pigmentation
- Controlled Roughness

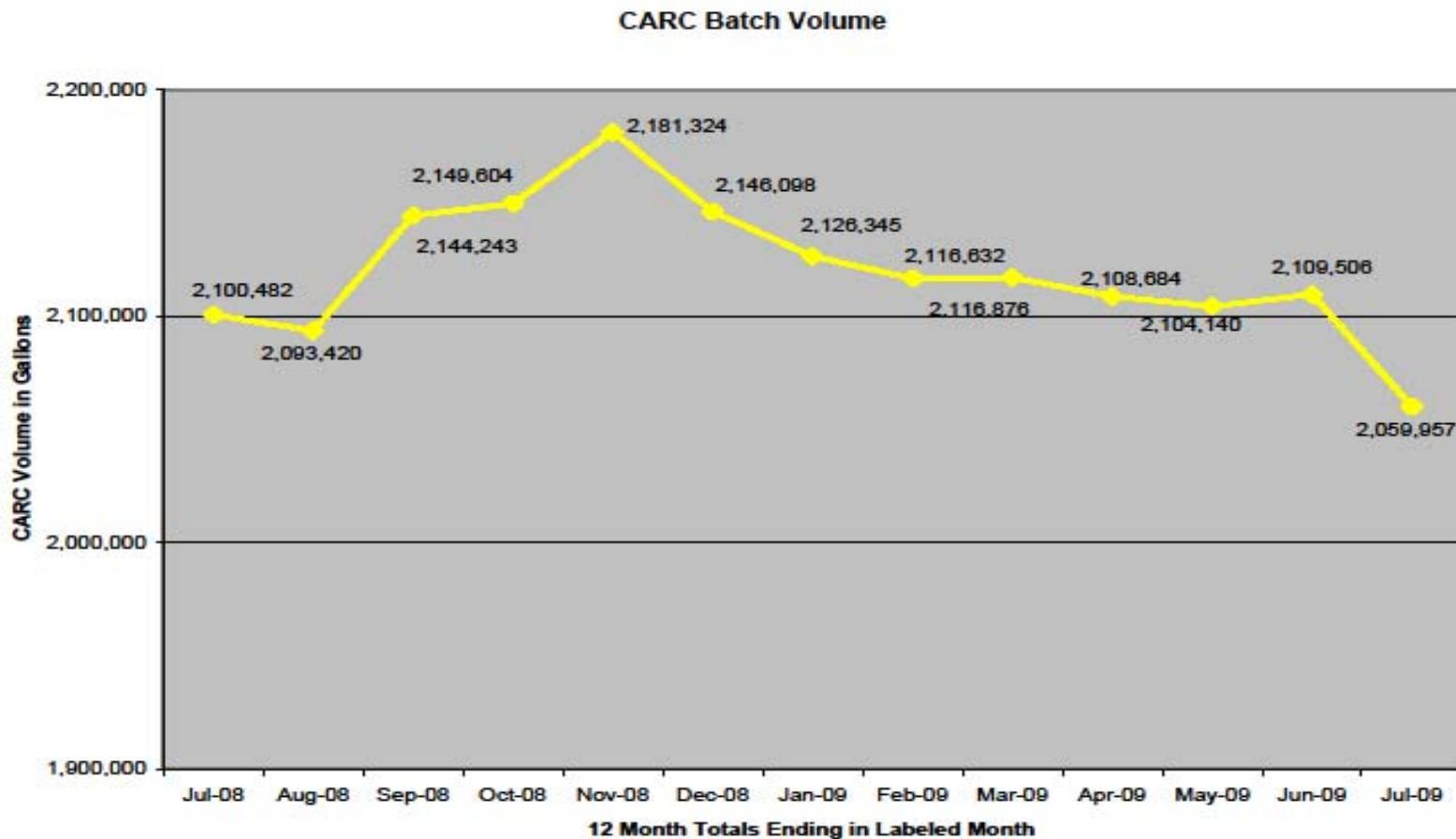
Functional Primer

- Corrosion Protection
- Texture

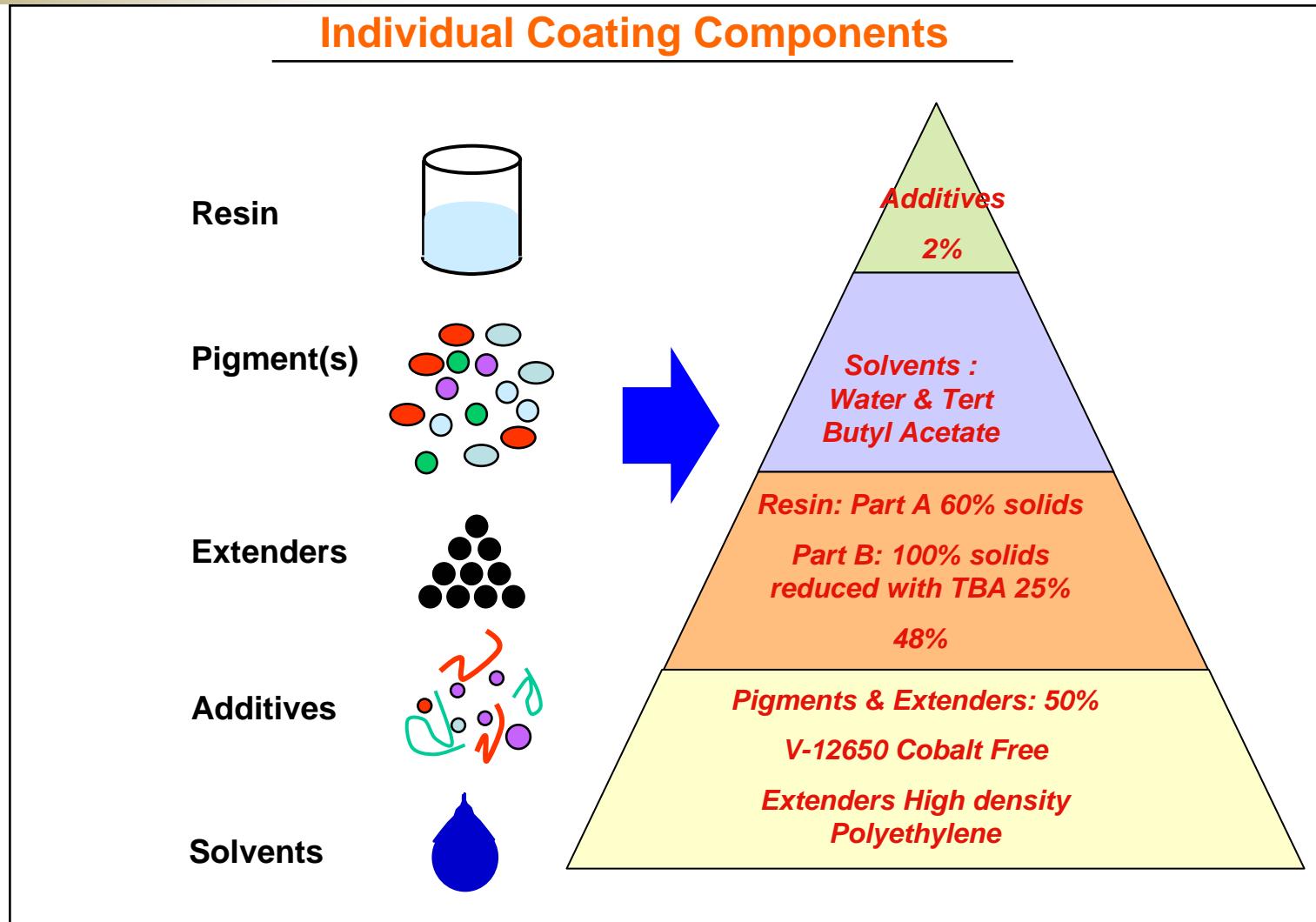
**Advanced Corrosion
Protection Layer**

- Substrate
- Ferrous
- Nonferrous
- Polymer Composite

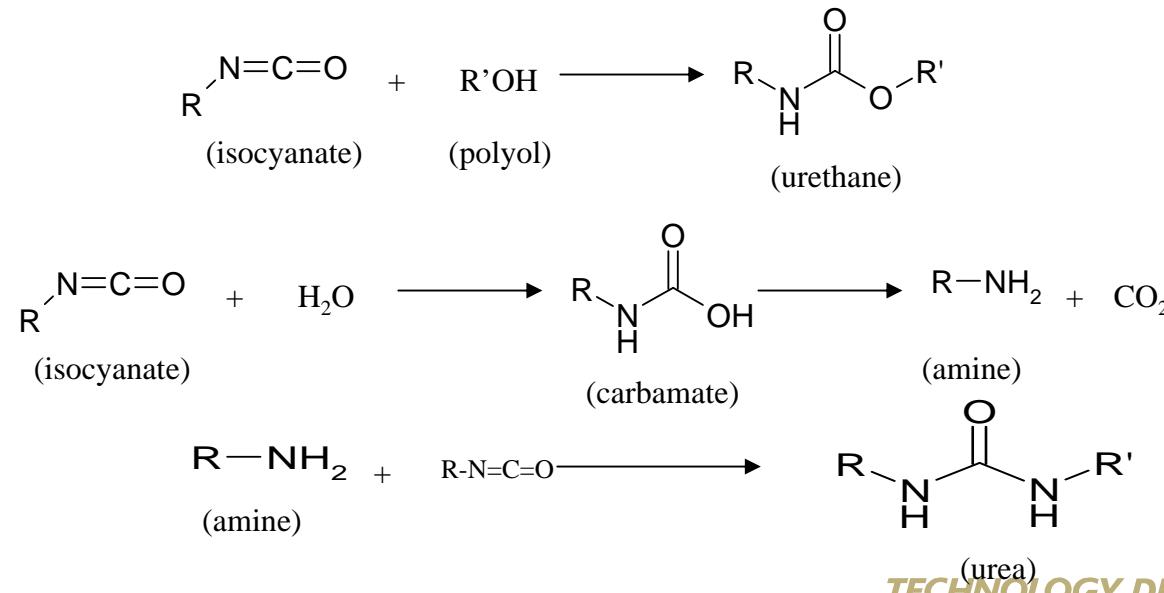
- Chemical Agent Resistant Coatings (CARC) is mandated by AR-750-1 for all tactical equipment.
- Every initial submission is fully tested and validated for Qualified Listing.
- Each batch from the initial submission is tested for color, gloss, IR and decontamination resistance. Included in the batch submission is batch volume. Next slide total volumes*
- Volume of coatings usage by Army is enormous: Several million gallons costing several hundred of millions of dollars annually will be reduced as developments are implemented and durability is improved.



- ❖ Recent Coatings represent superior durability, environmental compliance
- ❖ Stereotypes associated with Emulsions, Water Based or Hexavalent Chromium Free chemistries no longer hold true.
- ❖ Current efforts establishes solid foundation for present and future survivability enhancements and multifunctional capabilities
- ❖ Services are moving rapidly to eliminate standard coatings used and are implementing a new generation of coating technology throughout DOD

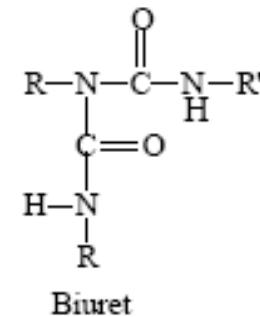
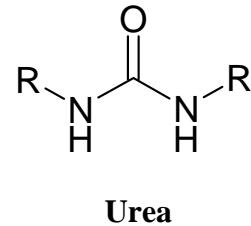
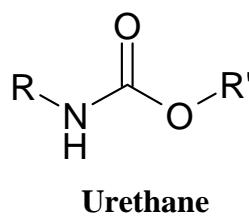


- **New Polyols**
 - Completely water soluble, no cosolvent needed
- **Tert-butyl acetate (VOC exempt) to dissolve and disperse isocyanate**
- **Attempt to reduce NCO:OH indexing to reduce solvent content**

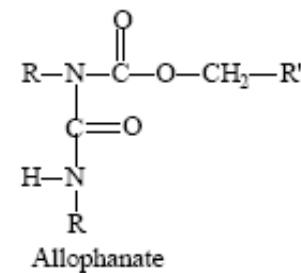


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

- Unacceptable CAR at NCO:OH < 4
- Moisture Cure uses blocked Isocyanate chemistry
- 2K Solvent systems typically 1:1.1 Ratio
- Adjust additives, reaction conditions, etc.
 - to make more favorable distribution

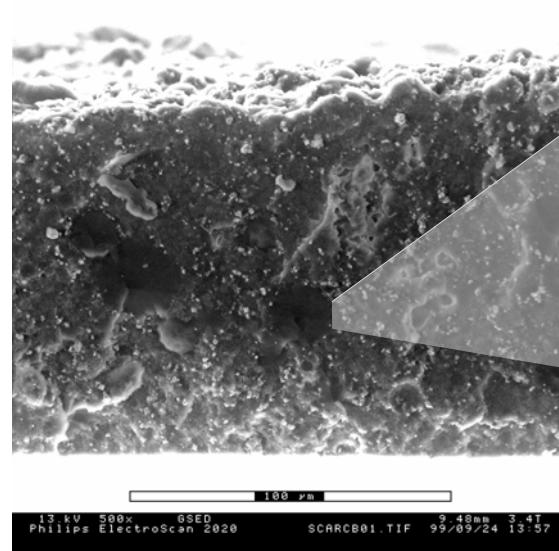


(Urea +
isocyanate)



(Urethane
+
isocyanate)

Polymeric beads



- **Integrated within Film**

- **Polymeric beads**
 - Reduce chalking effect
 - Improve UV resistance
 - Improve performance

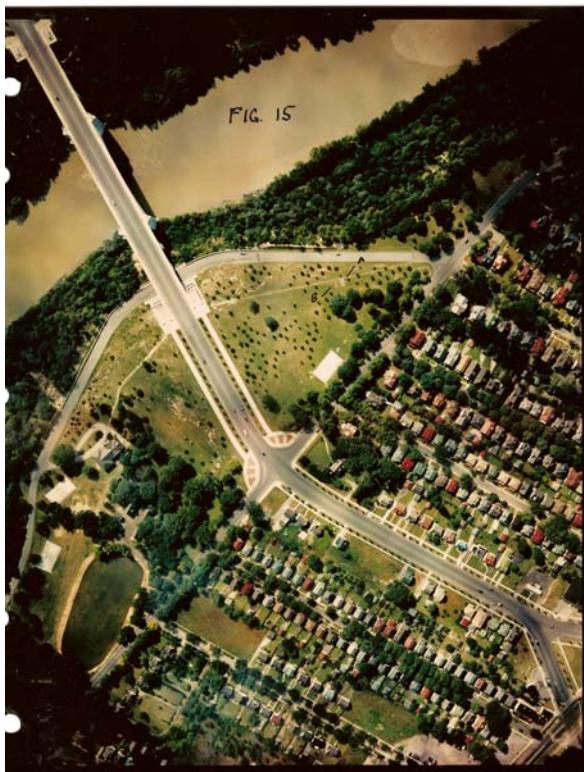
Diatomaceous silica

UNCLASSIFIED: Approved for public release; distribution unlimited.

Talc

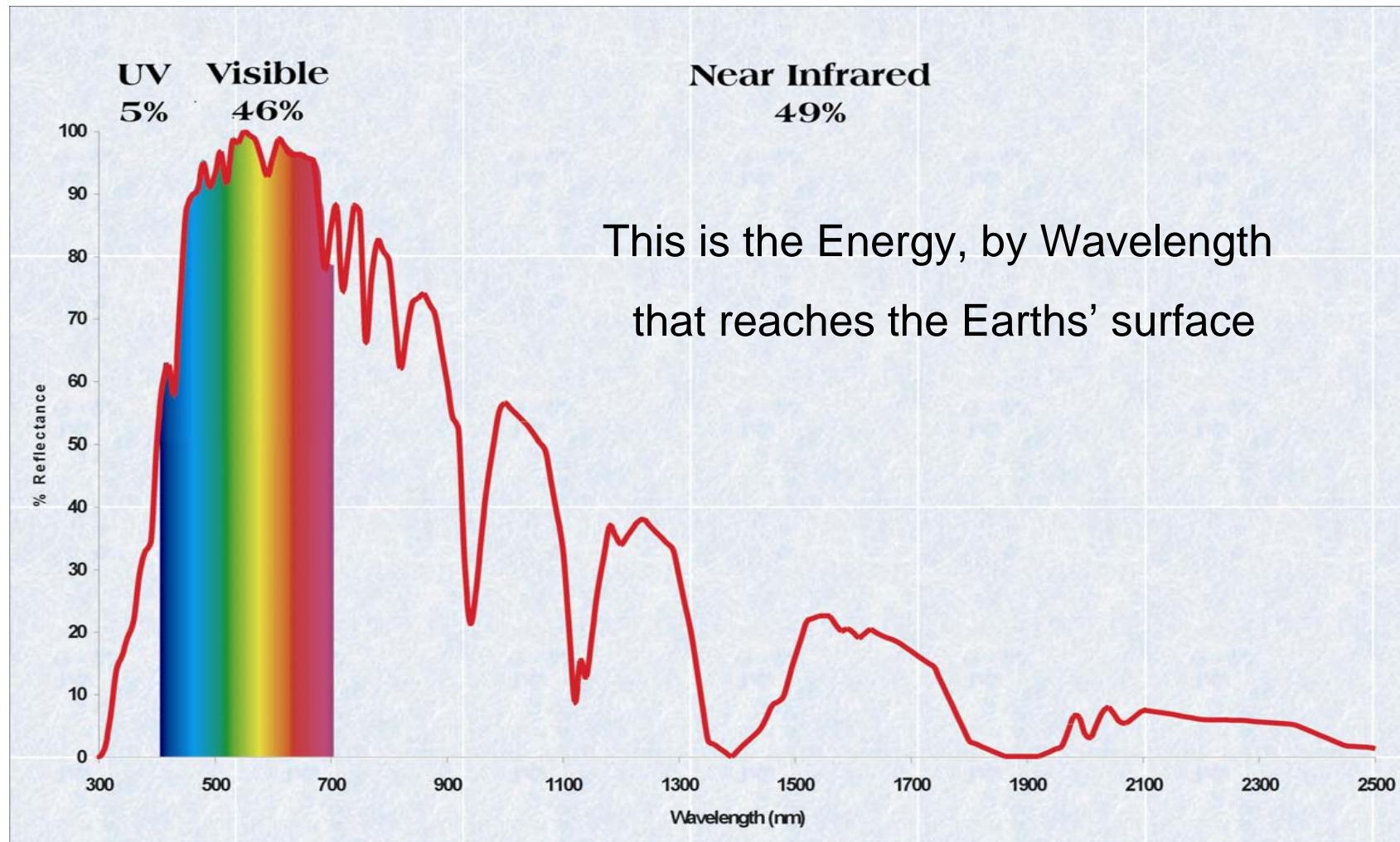
Objective:

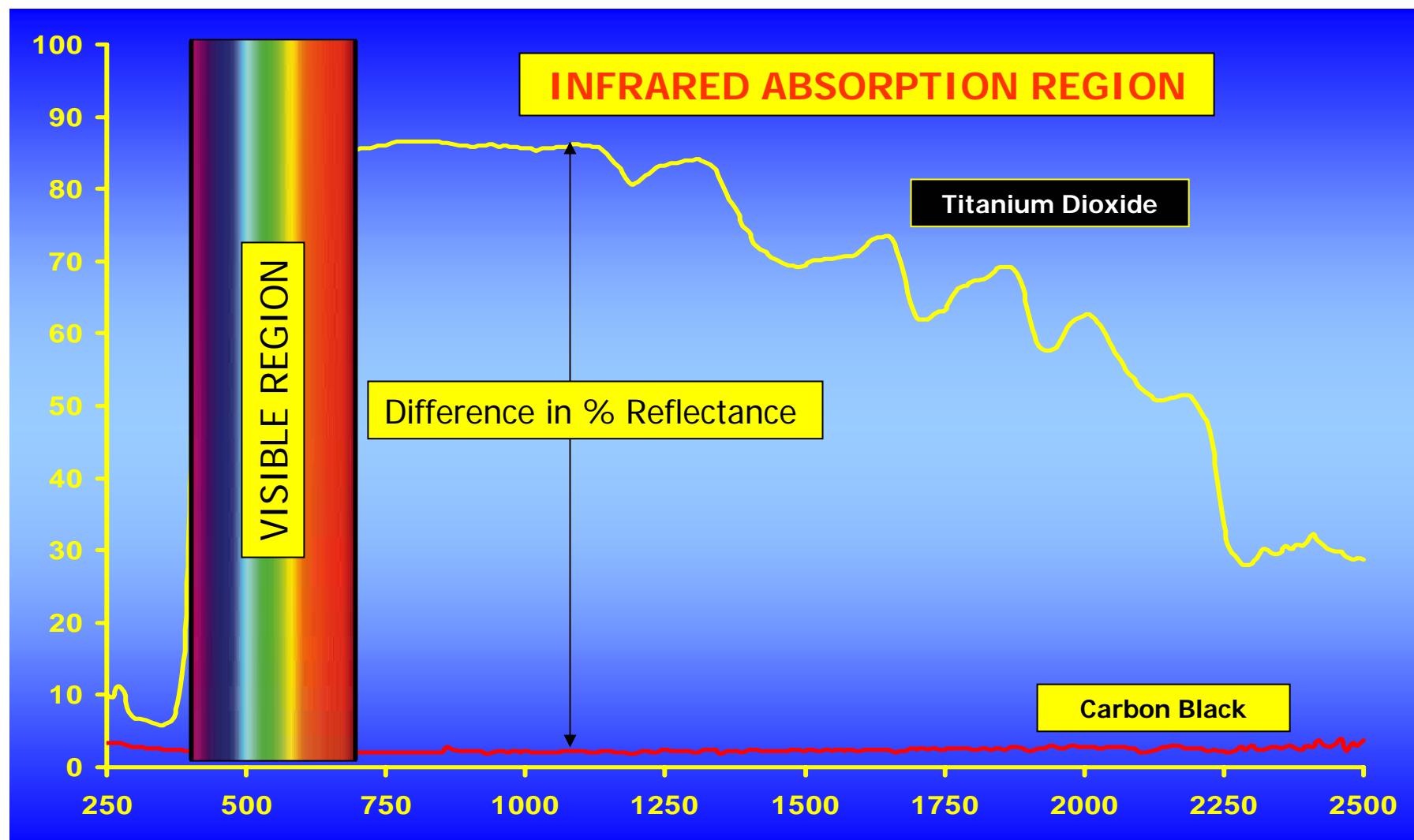
Provide advance coatings technology that will increase the functionality and durability of Army materiel



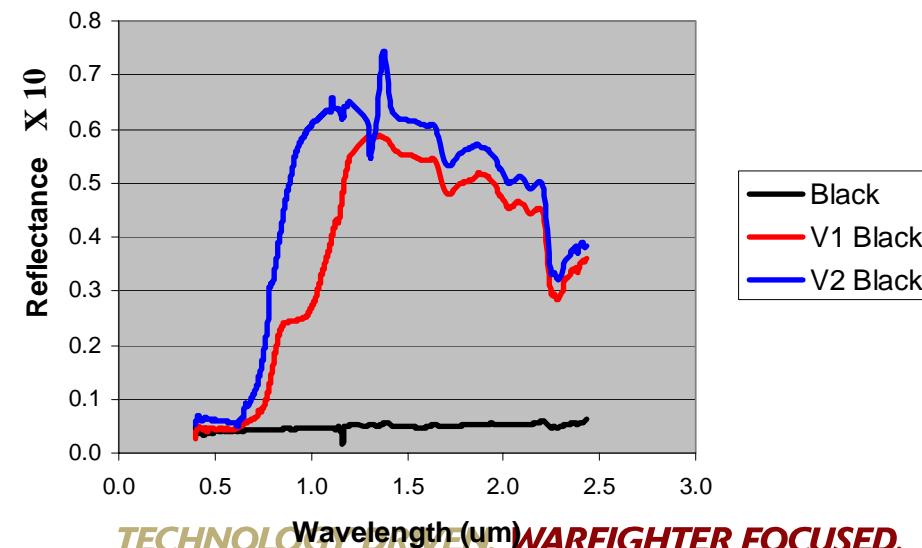
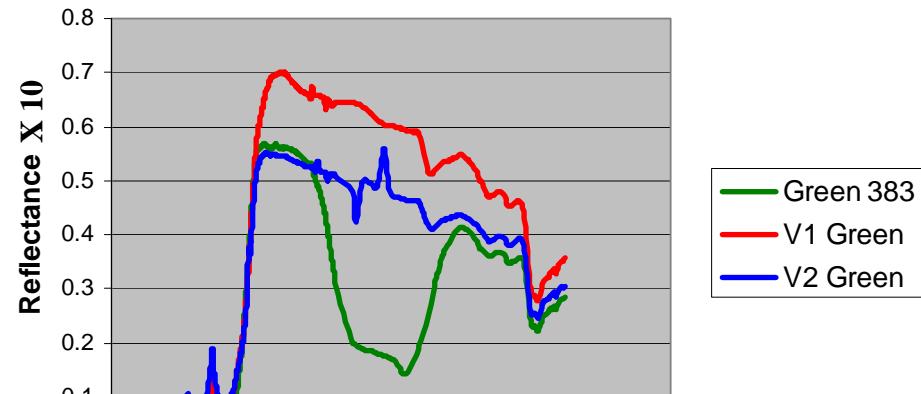
- 8 year weathering excellent: Less than 1.5 color unit change
- Formulated Primary Colors
- IR requirements will shift from 380nm -900nm to 380nm-2000nm with emphasis on 750nm to 1700nm.
- Visible unchanged
- Key highlight: COST, cobalt spinal increase of 300% and availability erratic.
- Formulation will be cobalt free for 383 Green, AC Green, 383 Brown
- Specification is currently being reviewed by vendors and government agencies
- **383 Green to change to 808 Green to identify change**

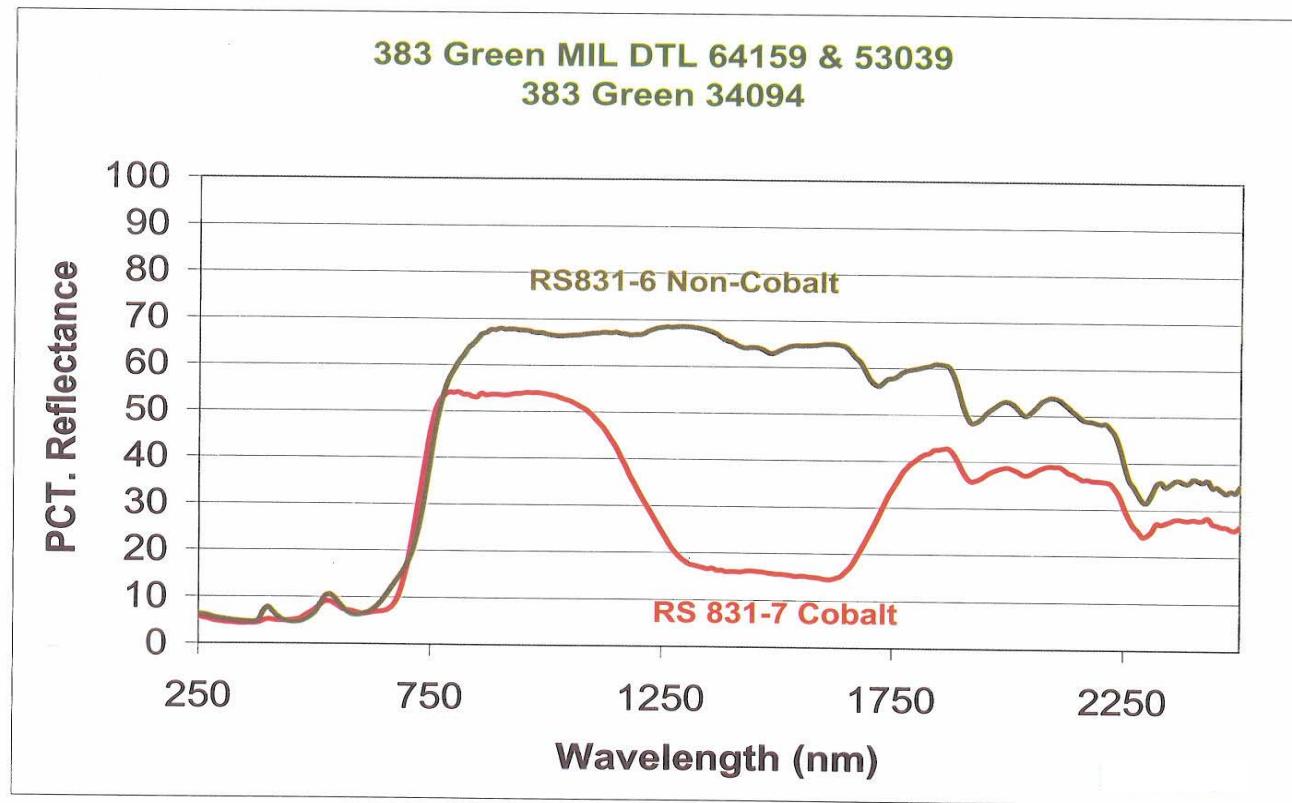
Sun's Energy Primarily in Visible & Infrared Spectrum



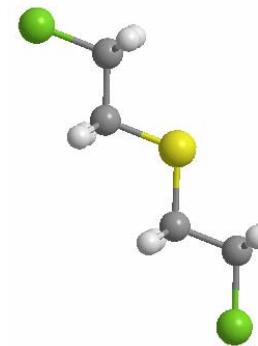
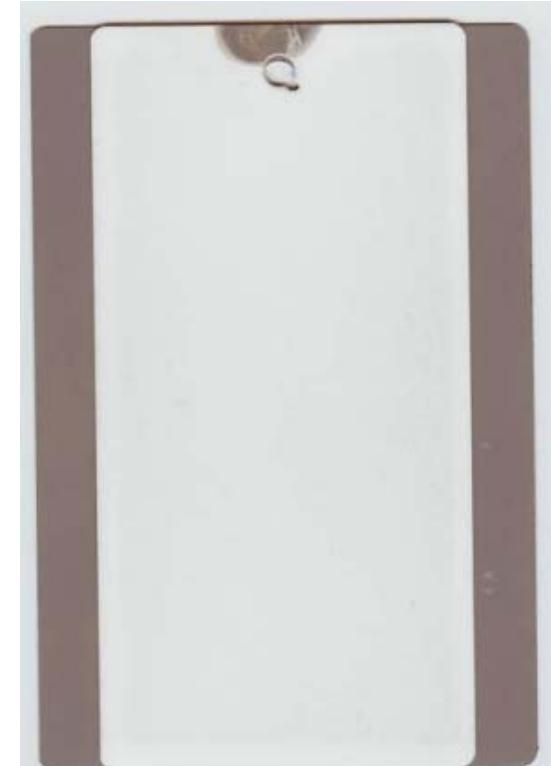
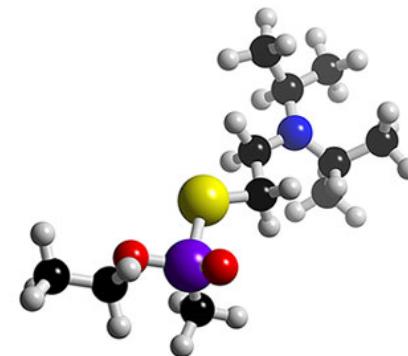


- ❖ Visually identical colors
- ❖ Higher Reflectance lower Temperature
- ❖ Reduce current coatings surface temperatures 20 to 50 Fahrenheit
- ❖ Major reductions in sustainability cost with extended coating life and with lower operating temperatures





- ARL formulated hybrid of UV initiated and Cross linked system
- Reduce Dry through cure to 15 minutes
- Excellent MEK resistance 17hrs
- Can create current color palate
- Industrial low cost lamps as only additional capital cost
- Will include as new type in our topcoat specifications
- Move toward Primers for rapid field repair and touchup



First Generation Coatings

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

- New types to include 1.0, .5 and zero VOC (Lbs/gal) with zero HAPs flattened with non-silica based raw materials.
- Inclusion of 34201 color (Woodland Desert Sage) Currently used on CH-47 and Foliage Green 504 (used on Helmets).
- Elimination of reference to MIL-T-81772 Aircraft Thinner (100% VOCs)
- Allowing vendors to provide exempt solvent package and provide a universal exempt solvent



MIL-DTL-53030 Water Based Epoxy & MIL-DTL- 53022 Solvent Based



- New type to include Enhanced Corrosion Resistance and require cyclic corrosion evaluation.
- 700Hrs Neutral Salt Fog
 - ASTM D610 RATING OF 9
 - ASTM D1654 RATING OF NOT LESS THAN 6 FOR STEEL
 - ASTM D1654 RATING OF NOT LESS THAN 8 FOR AL.
- 40 Cycles
 - ASTM D1654 RATING OF NOT LESS THAN 7 FOR STEEL & AL.
- Open to novel corrosion inhibitors
- Allowing vendors to provide exempt solvent package and provide a universal exempt solvent
- Similar effort to occur for 53022

- MIL-DTL-53084 and Powder to include the color Black.
- Open to novel corrosion inhibitors
- Powder Specification to include both Primer and Topcoat within same document
- Coordination Date 12/09

Multi-Substrates:

- Steel 1010, 1008
- Galvanized steel
- Stainless steel
- Al 2000/5000/6000/7000 series
- Ceramic/Composite
- **Coating:** must be compatible with existing military topcoats and primers
 - Three vendors have responded with products
 - SERDP effort with PPG & ARL for Zinc Phosphate Alternative
- **Process:** Depot and Repair

Aluminum Alloy 5059 For Armor Applications Foreign Comparative Test Program

- Updated military Al armor specification MIL-DTL-46027K
- Over \$14M to date in acquisition
 - \$12M+ in direct procurement of AA5059 for RG-33 MRAP
 - Over \$1.1M of acquisition by OEMs for internal testing, design, and prototyping
 - AA5059-H131 chosen as primary (100%) common hull material for all 8 variants of the PM FCS-BCT Manned Ground Vehicle (MGV) by Boeing (LSI), General Dynamics, and BAE Systems



MRAP RG-33



(8) MGV Mission Based Variants



- Related work - military specification MIL-DTL-32262 created for 6061 Al

- Current operations and future mission requirements have led to recent reassessments on Al for armor
 - AA5059-H131 (now in MIL-DTL-46027K)
 - AA2139-T8 (Under review for MIL SPEC addition)
 - Additional alloys & tempers
- Interest from U.S. Army and the USMC AA2139-T8 due to significantly improved mechanical properties and ballistics.



- The key hurdle is acquiring long term outdoor exposure data for platforms making current and near future decisions.
- Confidence that our accelerated screening processes are relevant to long term exposure results.
- Ensuring pretreatment and coating processes are followed accurately to enhance corrosion resistance and provide adequate adhesion/compatibility for subsequent coatings.

- **Phase I:** Manufacturer data, claims and performance parameters (acceptance based on environmental compliance, cost to include return on investment and process requirements)
- **Phase II:** ARL/TARDEC testing and evaluation of pretreatment or process using coupon panels to include accelerated and cyclic corrosion, EIS, and related adhesion type evaluations etc.
- **Phase III:** Application of component parts
- **Phase IV:** Outdoor exposure in corrosive environment of component parts (Items would be monitored for x years at 6 month intervals)
- This Phase type process would allow PMs to be aware of what items are currently being evaluated and also providing a certain level of confidence to select or use a particular new process. Baselines will be selected and used as standards for comparison. In this way new technologies can be evaluated and data acquired.

- Establish Baseline Coating System.
- Request other Services also establish Baseline Coating Systems.
- Assurance of film thickness and cure history.
- This would provide an opportunity to accurately compare data and perhaps support claims of “ Better or Enhanced”

Increased Options for Balanced Requirements

